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# MOSQUITOES

AND

# MALARIA

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BY

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# Mosquitoes and Malaria.

By Jacobus C. Faure, B.S., M.A., Division of Entomology.

## Preface.

Year by year mosquitoes cause many deaths and much sickness in malarious regions of the Union. The question of the prevention of malaria is one well worthy of consideration. This short discussion has been prepared, at the suggestion of the South African Anti-Malarial Association, with a view to giving a plain statement of the main facts of the relation of mosquitoes to fever, and suggesting the best methods of preventing the disease. The following is a brief résumé of the paper:—

Aside from the question of disease transmission, mosquitoes cause much discomfort. The well-established fact that mosquitoes are responsible for the spread of malaria and other human diseases makes it imperative that determined efforts should be made to combat mosquitoes.

Mosquitoes belong to the order *Diptera*, or true flies. They are aquatic in their larval and pupal stages. Only members of the sub-family *Anophelina* can transmit malaria. *Anopheles* and *Culex* (the harmless form) can be readily distinguished.

*Anopheles* flies and bites at night. It is a marsh mosquito, but breeds in other places as well.

Malaria can be prevented by choosing building sites away from rivers, streams, or marshes; by using mosquito nets; by living in mosquito-proof houses; by preventing the breeding of mosquitoes.

The human reservoirs, namely the native population and malarial patients, should be avoided by segregation and screening.

Emphasis is laid in this discussion upon the use of mosquito nets. House screening is strongly advocated, its additional advantages being pointed out.

The prevention of the breeding of mosquitoes by treating their breeding-places is the more fundamental method of control.

Co-operation in the community, and the necessity for municipal and Government action are mentioned.

The native population serves as the source of infection for the *Anopheles* mosquitoes. Natives (children especially) should live at least a mile away from Europeans.

Malaria has been known for many centuries. It has been one of the causes of the downfall of the Greeks and other races, and has kept civilization away from Africa. Sixteen years ago the mode of transmission of the disease was discovered. Since then the present methods of avoiding malaria have been devised.

Mosquitoes transmit malaria, and are a nuisance generally, but the need for action against them is intensified by the fact that they are responsible for the spread of yellow fever and elephantiasis, and probably other diseases of man and animals.

Finally the possibility of success, in view of what has been done elsewhere, is pointed out. We owe it to ourselves and the prosperity of the country to do everything in our power to avoid malaria.

## Introduction.

Most of us are so well acquainted with mosquitoes, as a result of our bitter experience with them, that it hardly seems necessary to describe them. When we consider mosquitoes merely as a nuisance the advisability of making systematic efforts to destroy them is very self-evident. But there is another, and far more important, consideration that puts the matter in a new light and emphasizes the necessity of concerted determined action along the line of preventing the breeding of mosquitoes; that is, of course, the fact that mosquitoes are responsible for the transmission of malaria and other important human diseases. Not only the actual discovery, made sixteen years ago, but also practical experience since 1900 has shown conclusively that the only way in which a healthy person can contract malaria is by being bitten by a particular kind of mosquito that has previously bitten a person suffering from malaria. There can be no shadow of a doubt that malaria is a mosquito-borne disease, and that the only way to combat malaria is to exterminate or at least greatly reduce the number of mosquitoes. This is no mere theory. Practical work done in many parts of the world against mosquitoes has shown that malaria is entirely preventable. And what has been done elsewhere can be done in the malarious districts of the Union, provided that the task is undertaken with a determination to succeed.

Before considering the control of the mosquito nuisance, let us briefly discuss the appearance, life-history, breeding places, and habits of mosquitoes in order to better understand the various methods by which they may be prevented from breeding.

## Mosquitoes.

Mosquitoes are small two-winged flies belonging to the large group of insects known as true flies (*Diptera*). The common house-fly is the best known member of this group. These insects have two transparent, membranous wings. They pass through several stages in their development, and are said to undergo complete metamorphosis, that is, the younger stages are entirely different from the adult, or full grown insect. The adult, or fly, lays eggs that develop into legless maggots or larvae. After a period of feeding the maggot changes to a pupa, that is, in most cases, entirely dormant. After a time the adult emerges from the pupal skin, and lays eggs from which maggots are again developed. Thus the life-cycle is completed.

Mosquitoes are characterized by their small size, long proboscis or beak, and comparatively long legs, and by the small scales present on the veins of the wings, especially along the margin. The adult possesses a long sucking beak or proboscis, and, besides the long slender (or feathery) antennae or feelers, two palpi or mouth-feelers at the side of the beak; these may be long or short. The eggs are laid in the water. The larvae, commonly known as "wrigglers," live in water. They differ from most fly larvae in possessing well-defined heads, are partly covered with long hairs, and have paddles at the tail end for swimming. They are about a quarter of an inch in length and can be readily recognized by their

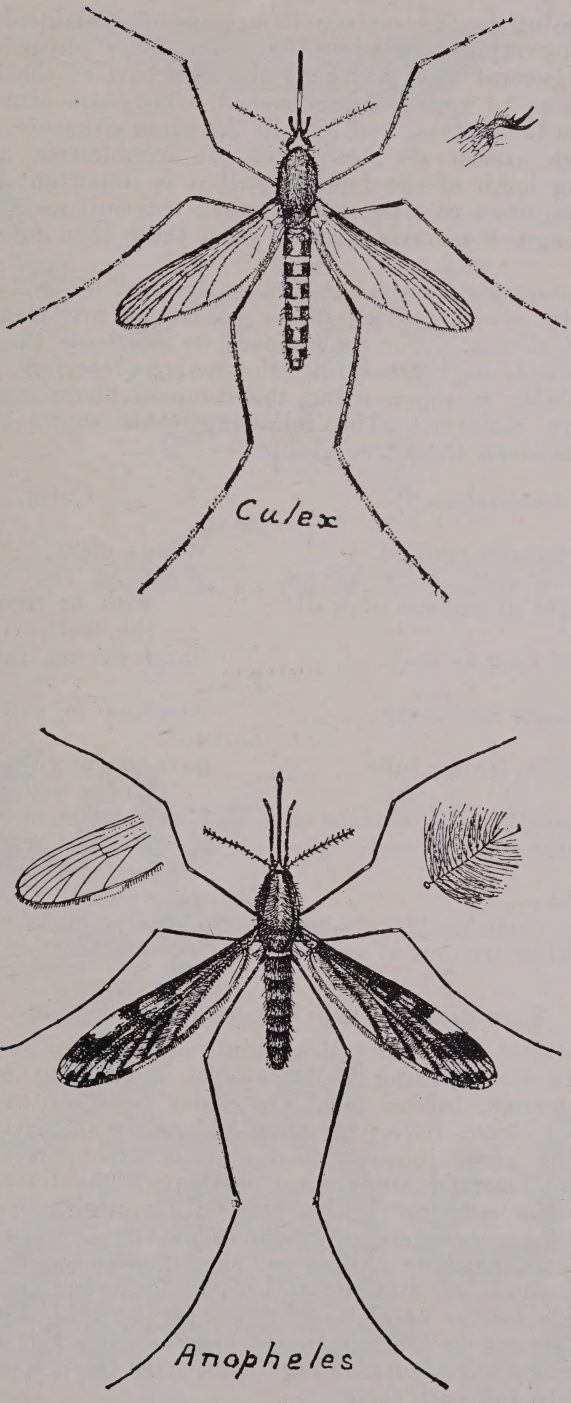


Fig. 1.—Female Mosquitoes. (*a*) Culex (above). (*b*) Anopheles (below). Greatly enlarged. (After Howard, U.S. Department of Agriculture.)

habit of coming to the surface to breathe and suddenly swimming downwards by rapidly twisting the body. The pupae resemble the larvae in a general way, but have the fore part of the body greatly enlarged, so as to appear hunchbacked. They are almost as active as the larvae themselves, and live in the same situation.

Although almost all mosquitoes are troublesome owing to the blood-sucking habit of the female, still it is important to know that only the mosquitoes of a particular group transmit malaria and to be able to distinguish malaria carriers from those that do not carry the disease.

Only mosquitoes of the sub-family *Anophelina* transmit malaria. The majority of mosquitoes found in houses are members of the sub-family *Culicina*. For convenience we shall use the name of the genus *Anopheles* as representing the malaria carriers, and that of the genus *Culex* as representing the common house mosquitoes that do not carry malaria. The following table shows the principal differences between these two groups:—

| *Anopheles*. | *Culex*. |
|---|---|
| *Adult.* | *Adult.* |
| Wings usually spotted. | Wings clear. |
| When at rest, body at an angle to surface of wall. | When at rest body parallel with or almost touching the wall. |
| Palpi as long as beak. | Palpi shorter than beak. |
| *Eggs.* | *Eggs.* |
| Laid singly on water. | Floating in raft-like masses. |
| *Larvae* | *Larvae* |
| have no breathing tube. | have a long breathing tube at the end of the body. |
| Body parallel with surface of water when at rest. | Hang, when at rest, with the body at an angle to the surface of the water. |
| *Breeding-places.* | *Breeding-places.* |
| Usually earth pools or edges of slow streams or ponds. | Usually tanks, barrels, old tins, bottles, and the like. |

## Life-history and Habits of Anopheles.

The *Anopheles* mosquito flies mainly at night, or just at sundown and early in the morning. During the daytime it hides in dark corners of houses, behind curtains, under beds, or in trees. The female sucks blood, living on man and other animals. The male feeds only on plant juices. The male differs from the female in having broad feathery antennae. Ordinarily the females bite only at night. The eggs are laid singly on the water, or near it, but they often float together in irregular groups. In warm weather they hatch out in a day or two. The larva lives only in water, so that the presence of mosquitoes always indicates the presence of water suitable for the breeding of larvae in the neighbourhood. The larva has to come to the surface to breathe, and this fact gives us a very easy method of destroying them, namely, to pour oil on the water so as to suffocate them.

*Anopheles* is principally a marsh-breeding mosquito, whereas *Culex* ordinarily breeds in the small collections of water around

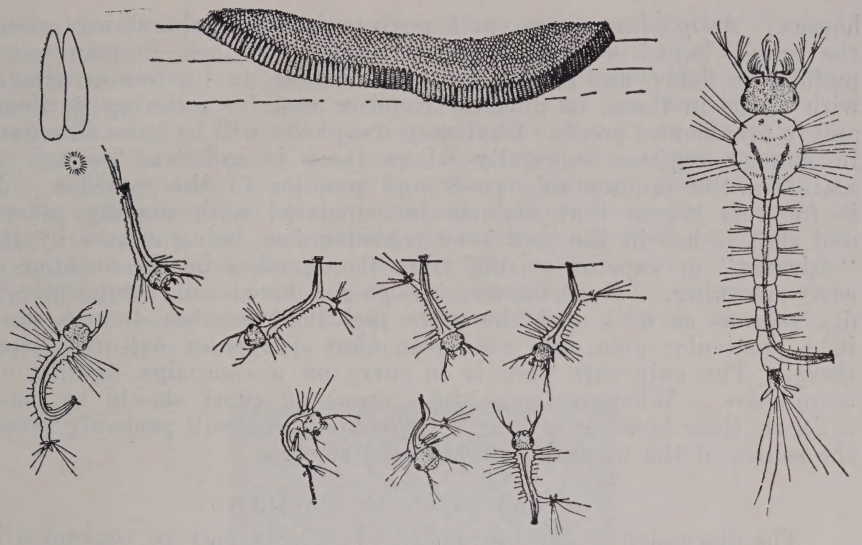

Fig. 2.—Culex Mosquito, egg mass above, young larvae below. Greatly enlarged.
(After Howard, U.S. Department of Agriculture.)

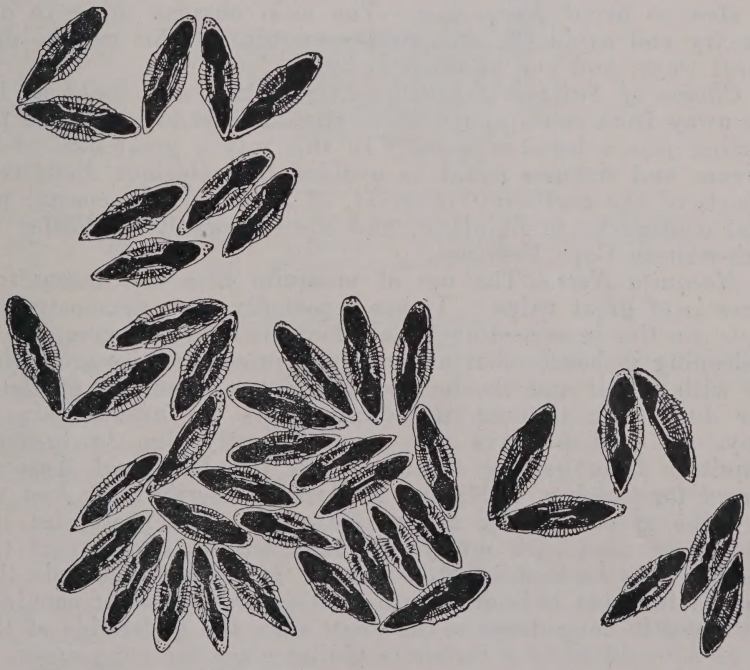

Fig. 3.--Anopheles Eggs floating on the water. Greatly enlarged.
(After Howard, U.S. Department of Agriculture.)

houses. *Anopheles* prefers earth pools. It breeds abundantly along the grassy banks of slow streams, ponds, and lakes, in rain water puddles in fields, and along roads, in marshes, in furrows or ditches with weeds in them, in tanks or cisterns used for watering gardens, and in ornamental ponds. Obviously *Anopheles* will be more abundant in marshy regions, especially where there is sufficient rainfall to maintain the innumerable pools and puddles in the marshes. It is for this reason that malaria is associated with marshy places, and that it has in the past been considered as being caused by the "miasms" or vapours arising from the marshes in the evening or early morning. Nevertheless, *Anopheles* breeds in comparatively dry regions as well, and the mere fact that marshes do not occur in a particular area does not mean that *Anopheles* will not breed there. The only safe plan is to carry on a campaign against *all mosquitoes*. Whenever mosquitoes occur an effort should be made to locate their breeding places A careful search will probably reveal the source of the mosquito supply soon enough.

## The Prevention of Malaria.

The discussion of the prevention of malaria may be conveniently considered under the following headings: (*a*) How to avoid mosquitoes, (*b*) how to destroy mosquitoes, (*c*) methods to avoid human sources of malaria, (*d*) treatment of patients.

Paying attention to the mosquitoes is, of course, the most logical procedure in any attempt made to reduce malaria, because it strikes at the root of the trouble by removing the agents by which the disease is transmitted.

*How to avoid Mosquitoes.*—The most obvious thing to do first is to try and avoid the *Anopheles* mosquito. This can be done in several ways, and one of them is by

*Choice of Suitable Locality.*—Always try and build at least a mile away from swamps, rivers, or streams that are liable to furnish breeding places for *Anopheles*. In this way a great deal of inconvenience and sickness could be avoided in malarious districts, such as parts of the northern Transvaal, of Zululand, the coastal part of Natal contiguous to Zululand, and the Orange River Valley in the north-western Cape Province.

*Mosquito Nets.*—The use of mosquito nets and mosquito-proof houses is of great value. It has repeatedly been demonstrated that people can live in exceedingly malarious districts with complete safety by sleeping in houses that are mosquito-proof, and by protecting the face with a veil and the hands with gloves when out of the house after dusk. In the use of mosquito nets the utmost care should always be used to have the net sufficiently fine to prevent the mosquitoes from getting through. In the *Transvaal Agricultural Journal* for October, 1907, Dr. F. Arnold described the best nets to use. The accompanying figure illustrates the largest size netting that can be used with safety. It goes without saying that the net should always be kept in good repair. If there is one hole the size of a pea in a net it is of no use whatsoever. The net should never be allowed to hang down to the floor, since the under-side of the bed has been found to be a favourite hiding place for mosquitoes. Tuck the net in under the mattress very carefully on all sides. The tighter the net is stretched the better the ventilation will be. Of

course the bed should be large enough to prevent any part of the body from touching the net and thereby being exposed to the mosquitoes. The net sewed on to a round top and suspended from the ceiling over the bed is generally in use in South Africa and has been found to be very successful. It is also very important to use a net when sleeping on the veld in malarious districts. Four upright rods can be attached to a folding stretcher. Over a cord run through rings in the top of the rods a box-shaped net is thrown. Here, as in the case of nets used in houses, the net should be carefully tucked in under the mattress—or folded blanket used for the purpose—on all sides, and should not be allowed to hang down upon the ground. Excellent tents and camp beds already fitted with mosquito netting can now be purchased at a reasonable price.

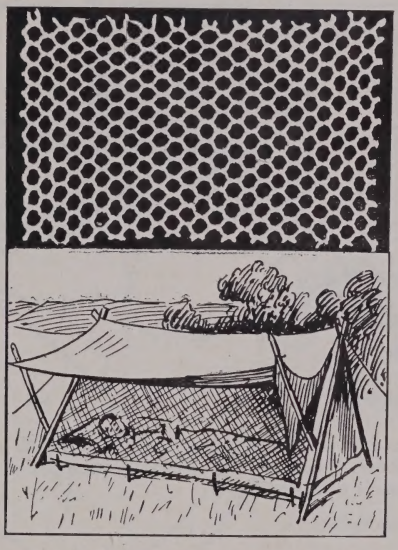

Fig. 4.—Mosquito Netting. Specimen of proper mesh to use above. Below, a camp-bed, protected by netting. (Loaned by the South African Anti-Malarial Association.)

## House Screening.

It is very much more desirable to live in mosquito-proof houses than to rely merely upon mosquito nets. Screening may perhaps appear to some to involve an unnecessary expenditure of time and money. By screening one can keep house-flies out of the house and also avoid the annoyance of beetles, moths, and midges that are attracted to lights at night. Considering that house-flies are dangerous carriers of intestinal and other diseases it is very advisable indeed to exclude them from our houses and particularly from our kitchens and dining-rooms. Having a screened house, and if possible a screened veranda, one can live in security and comfort in malarious regions. It should not be forgotten that disease carrying mosquitoes are quite liable to bite while one is sitting on the veranda or indoors after dusk. This point further emphasizes the fact that a properly screened house is a necessity if comfort and safety are to be had.

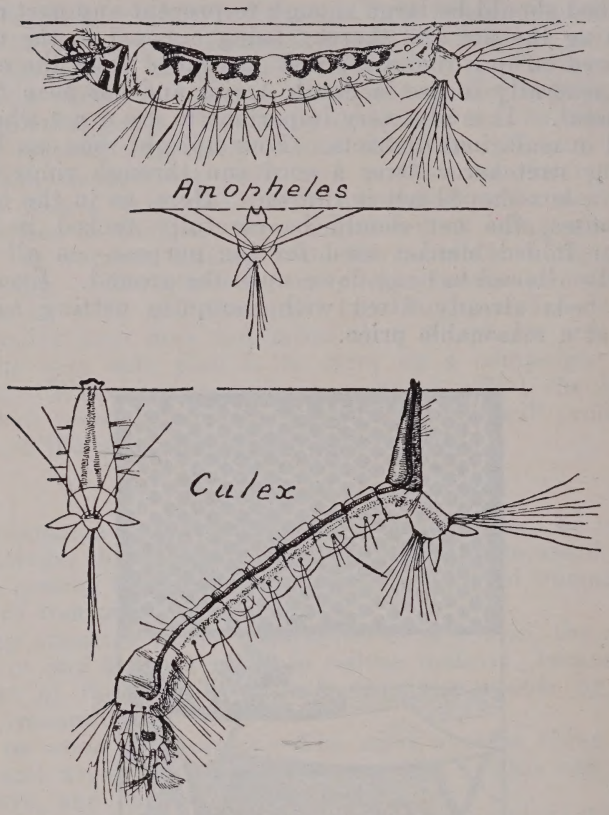


Fig. 5.—Mosquito Larvae in resting position, just beneath surface of water. Anopheles above, Culex below. Greatly enlarged. (After Howard, U.S. Department of Agriculture.)

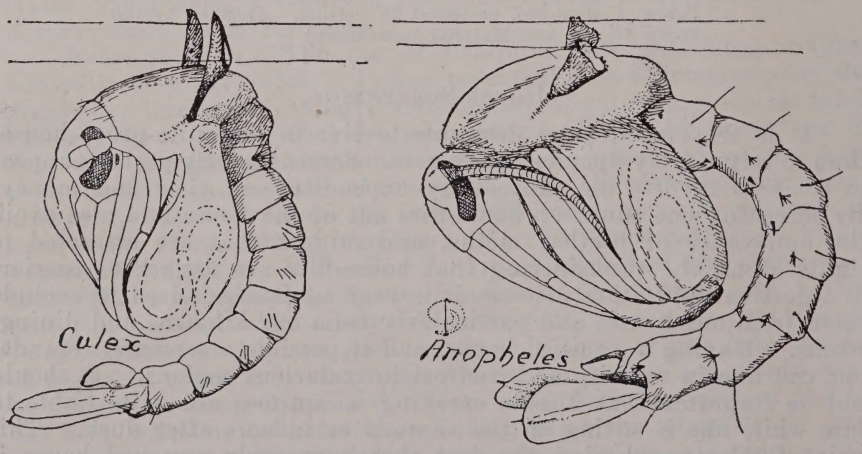


Fig. 6.—Mosquito Pupae. Culex at left, Anopheles at right. Greatly enlarged. (After Howard, U.S. Department of Agriculture.)

For screening purposes a fine wire gauze should be used. Mosquito netting rots away too soon for use outdoors. Wire of eighteen or sixteen meshes to the inch is the best to use. "Tinned-iron" screen is perhaps cheapest and most easily obtained. Copper or brass wire is much more permanent and reliable, but it costs more. Sliding sash windows can be very easily screened by means of a close fitting wooden frame covered with gauze that fits on to the outside and is held in place with hooks and can be removed when the windows are washed. The gauze may be nailed on to the outside of the sashes of fanlights and windows that open inwards on hinges. Windows that open outwards present more of a problem. The best in the end will perhaps be to refit the windows to open inwards and to put the gauze outside.

For doors the ideal is to have automatic swinging screen doors with a screened porch or veranda, also with a swinging door. In this way the door is double screened. Ordinarily, however, a single-

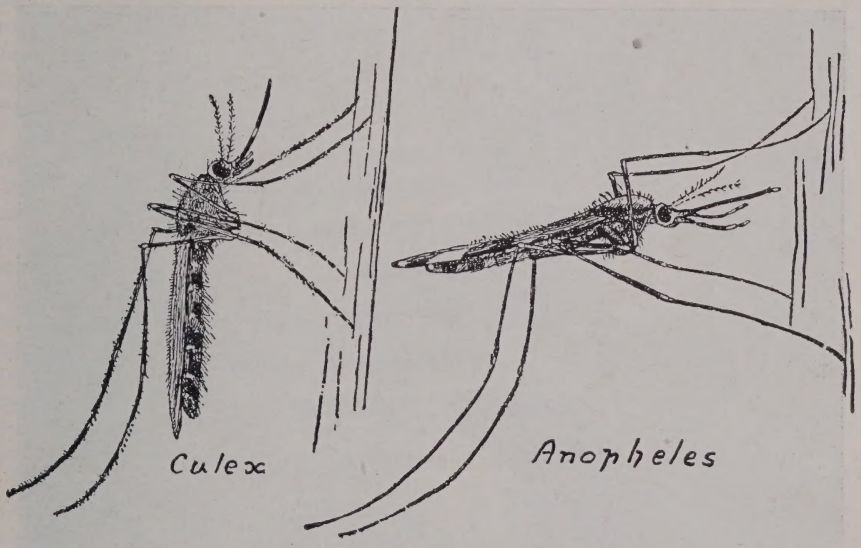


Fig. 7.—Adult Mosquitoes in resting positions. Culex at left, Anopheles at right Greatly enlarged. (After Howard, U.S. Department of Agriculture.)

screen door, close fitting, and kept in good repair, will answer for the purpose. It is necessary to close up or screen chimneys that are not in constant use, and also all other holes or cracks. The details of screening can best be worked out in each particular case, as long as the object is understood and kept in mind, namely, the exclusion of all mosquitoes from the house.

Too much emphasis cannot be laid upon the great advantages of a mosquito and fly proof house. In malarious districts it is an absolute necessity to protect oneself from the bites of mosquitoes if malaria is to be avoided. House screening is undoubtedly the best protection. Almost everywhere in South Africa mosquitoes are more or less of a nuisance, and insects attracted to lights certainly cause considerable annoyance. Proper house screening will largely prevent these troubles. Then there is the house-fly that is always with us.

Keeping this insect out of our houses, and at least out of our dining-rooms and kitchens, is a very sadly neglected precaution against enteric fever, infantile diarrhœa, and other diseases. Screening will keep out the house-fly. To any one accustomed to the comfort resulting from house screening in the United States, where it is a common practice to screen houses even in the ordinarily non-malarious north, it is very discouraging indeed to notice how few people in South Africa, even of those who are very well off, avail themselves of this simple method of avoiding the annoyance and danger of house-flies and mosquitoes.

Merely putting up the screens on the windows and doors does not complete the task. Constant care must be exercised to see that there are no holes in the screens and that the springs on the doors always work properly. A crack a quarter of an inch wide left open in a door or window of a room is enough to remove all the benefit of

Fig. 8.—Typical Anopheles Breeding Place.

screening. These are the little things that may escape us. Such gross neglect as to leave the screen door of a dining-room standing open during meal hours is of course absurd. This is mentioned here because only recently the writer missed having a very enjoyable meal in a large dining-room literally swarming with flies. The room had been fitted with screens, but one of the screen doors was wide open, and the room had been converted into a huge fly-trap!

## How to Destroy Mosquitoes.

Protecting ourselves from malaria-carrying mosquitoes by means of mosquito nets and mosquito-proof houses is, however, not the most satisfactory method of preventing malaria. There is another more

fundamental method of avoiding the mosquitoes, and that is to attack them by preventing their breeding.

### Prevention of the Breeding of Mosquitoes.

As has been pointed out above, all mosquitoes are aquatic in their larval and pupal stages. They breed in almost any pool or receptacle of stagnant or semi-stagnant water. Given a locality that is malarious, or one in which mosquitoes are troublesome, the first thing to be done is to locate the mosquito breeding places. A careful inspection of the premises around mosquito plagued houses or of the neighbourhood ought to show where the mosquitoes come from. It should be remembered that a rain barrel half full of water, a paraffin tin, or old bucket, or a few bottle-ends containing water in some neglected corner may furnish an abundant supply of mosquitoes for many weeks. In the case of small towns, or in the country, the streams, pools, and swamps should also be examined. Once the breeding grounds are located, there are various ways in which the mosquitoes may be prevented from breeding. In malarious regions the question of *Anopheles* breeding places is of the greatest importance. Since *Anopheles* generally breeds by preference in swamps, slow-flowing streams, and pools in the ground, the treatment of such breeding places is of most importance in connection with the prevention of malaria.

*Drainage* will undoubtedly prove to be the most thorough and far-reaching method of preventing the breeding of *Anopheles* and other mosquitoes. Some extremely successful work has been done along this line in New Jersey and in California, in the United States. Certain swampy areas in New Jersey, near New York City, had long been famous for their mosquitoes. By an elaborate system of marsh drainage the number of mosquitoes has been very materially reduced, the region has been made comfortable for summer visitors, and the value of real estate has been considerably increased. Aside from the question of the prevention of the breeding of mosquitoes, the drainage of swamps or vleis is a good agricultural practice.

For a given mosquito breeding swamp a system of ditches should be planned, with smaller ones leading into a main channel, so as to remove the water standing on the surface. Care should be exercised to make the ditches as straight as possible, with compact sides, and to keep them free from weeds or other obstructions, because a neglected ditch may merely furnish additional breeding grounds for the mosquitoes.

Closely associated with drainage is the plan of cleaning up the banks of streams. *Anopheles* often breeds in the quiet pools formed by reeds and other plants growing along the banks of streams. Such stream banks should be thoroughly cleaned, so as to ensure a clean flow, without the damming behind or between bunches of reeds or the like. The same applies to large irrigation furrows or drainage ditches.

Ordinarily drainage will probably be too extensive and costly an undertaking for an individual farmer. Mining companies, real estate societies, municipalities, and railroad administrations can, however, make excellent use of this method of preventing mosquito breeding. It is such a safe method that the results will surely repay the initial expense and trouble.

Where drainage cannot be undertaken on account of the expense, or because it is impractical, breeding pools can be treated with paraffin oil. Of all the various culicides (substances used to kill mosquito larvae) that have been tried in many parts of the world by investigators, paraffin oil has given the best results. Mosquito larvae have to come to the surface of the water to breathe, and a thin film of oil upon the surface prevents them from breathing and thus kills them. The oil can best be applied by means of a knapsack sprayer or garden syringe, as spraying the oil on the water in a fine mist ensures its spreading out in a uniform film all over the surface. The process of oiling will probably have to be repeated every week or ten days. This method is very useful for rock pools, or water in deep holes that cannot be drained off. Cisterns or other receptacles that cannot be screened can also be effectively treated with oil when the water is

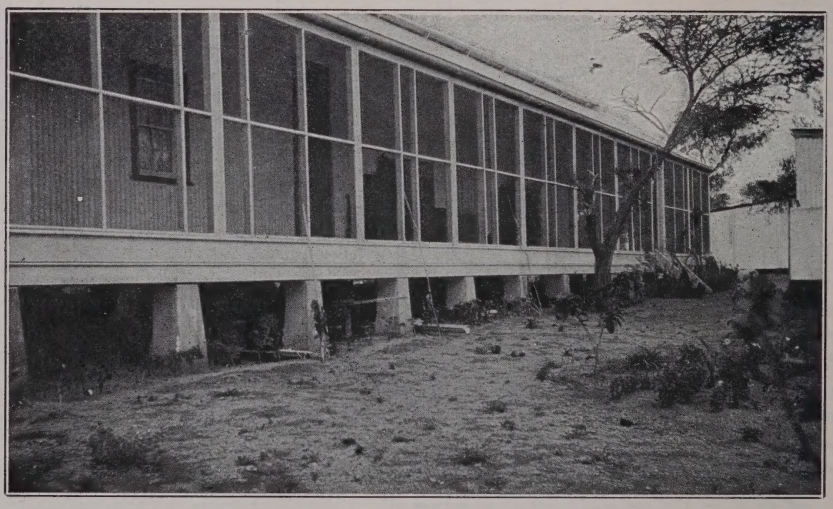

Fig. 9.—Mosquito-proof House. Note framework for screen on stoep.
(Photo loaned by South African Anti-Malarial Association.)

drawn from them by means of taps. Even the rain water tank that is so commonly used in South Africa can be treated in this way, and a thin film of oil on the surface need not impair the value of the water for drinking purposes as long as there is a fairly large quantity of water in the tank.

Where water tanks or cisterns are used, they should be carefully closed or screened with netting or gauze to prevent the mosquitoes from getting to the water in order to lay their eggs. If screening is not practical, a thin film of oil should be maintained on the surface. Only recently a farmer complained to the writer about mosquitoes. Examination showed that there were a number of larvae present in his two rain water tanks at one side of the house. Probably in nine cases out of ten people who are troubled by mosquitoes will be found to breed them in abundance in their water tanks or in some neglected half-barrel of rain water or the like.

In the campaigns against the yellow fever mosquito, which is essentially a house mosquito, breeding in various small collections of water, in New Orleans, U.S.A., one of the mosquito brigades had the particular duty of screening all the cisterns and water tanks in the city.

Although *Anopheles* does not ordinarily breed in odd collections of water in tins, barrels, and the like, still the best principle is to prevent the breeding of all mosquitoes. One of the simplest, and therefore one of the first things to do in trying to prevent mosquito breeding in a given locality is to systematically remove all receptacles that may furnish breeding places for mosquitoes. Attention should be paid to old tins and broken bottle-ends lying about in fields. Even on well kept premises one will very often find a paraffin tin half full of water, or six inches of water in an old barrel, or a row of empty bottles behind the stable in which rain water may collect, and many other similar places where mosquitoes may and do breed. All such articles should be taken away, destroyed, or turned over so as to remove the water. Any collection of water that cannot be readily removed may be oiled. The rain water gutters on houses should also be examined. It has been observed that when water collects in them due to stopping up by leaves or some other material, mosquitoes may breed in such gutters.

### Natural Enemies of Mosquitoes.—Introduction of "Millions" into South Africa.

Mosquitoes have many natural enemies, especially in their larval stages. Various predaceous insects, such as diving beetles and the larvae of dragon flies destroy the larvae under natural conditions. Certain fish are also very important factors in keeping mosquitoes under control. Some of the smaller kinds, such as minnows, are especially fond of wrigglers. Fish may be introduced into lily ponds in parks or private gardens in order to prevent mosquitoes from breeding in them. The South African Anti-Malarial Association, in conjunction with the Government, has recently imported a shipment of fish from the West Indies with a view to studying their usefulness as mosquito destroyers in South Africa. The fish in question is a small minnow, popularly known as "millions"; it is a very important enemy of mosquito larvae in the West Indies. Results achieved to date at the Government Fish Hatcheries at Stellenbosch are encouraging, and it is hoped that the fish may in the future be introduced into the streams in malarial regions of South Africa.

### Co-operation.

Individual property owners and land or mining companies can do a great deal of good work against mosquitoes, but in malarious districts really effective work can probably only be done by muncipalities or by Government. The reason for this is simply that the work will usually be too expensive and extended for individual effort. Everything, however, should not be left to the municipality or the Government. If the individual cannot prevent mosquitoes from breeding in his neighbourhood he can at least see that none breed on his premises, and he can protect himself, his family, and his employees from mosquitoes by screening his house. Organized effort in a community

can also do much towards urging the governing body on to action. Local organizations, such as branches of the South African Anti-Malarial Association, are to be welcomed, because they can do a great deal of good by educating the public and asking Government and local authorities to act.

Where the malaria problem is a serious one, indifferent or indolent residents might be forced to adopt anti-mosquito precautions, such as screening, by law. If laws are made and strictly enforced in order to prevent stock diseases in South Africa, they can surely also be employed, when necessary, in order to prevent malarial fever.

### Methods to Avoid the Human Sources of Malaria.

The methods of avoiding the disease-carrying mosquitoes have now been considered, namely keeping them away from us and preventing them from breeding. Another important feature of the malaria and mosquto problem is that of the sources of infection. It should be clearly understood that the *Anopheles* mosquito is perfectly harmless

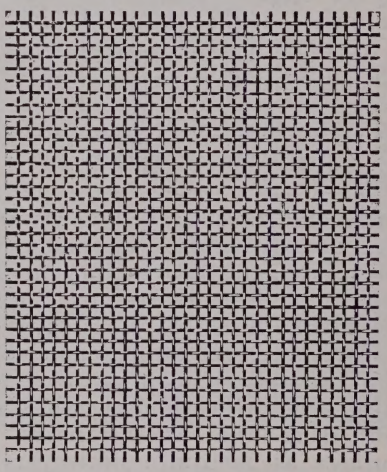

Fig. 10.—Proper Mesh of Wire Gauze to be used for house-screening.
(Loaned by the South African Anti-Malarial Association.)

as long as it has not had access to a person who has the malaria parasites in his blood. If there were no human reservoirs of malaria in a neighbourhood, thousands of *Anopheles* could not produce a single case of malaria. The mosquito is merely an agent in the transmission of the parasites from a diseased to a healthy person.

Investigators in many parts of the world have shown that a very large percentage of the natives in malarial regions have the malaria parasite in their blood. Native children are reservoirs of infection for the Europeans living amongst them. After a long series of attacks most natives become immune to malarial fever.

Dr. L. Bostock, formerly Railway Medical Officer at Komatipoort, found, by actual examination of the blood, that practically all young natives in the low veld of the Transvaal harbour the parasite of malaria in their blood. Probably the same conditions exist in other

malarious parts of the Union. It follows directly from this that wherever there is danger of malaria native children should not be allowed to live closer than one mile to the dwellings of Europeans. By means of such segregation the danger of being bitten by an *Anopheles* infected with malarial parasites will be greatly lessened.

### Treatment of Patients.

In the treatment and care of malarial patients one of the very important things to do, for the sake of the community, is to see that such patients are properly screened. Even in regions where malaria is not ordinarily contracted, there always is a possibility of *Anopheles* mosquitoes obtaining the parasites from some one who comes in from a

Fig. 11.—Mosquito-proof Tent used by Dr. Turner. Note net in door. (Photo loaned by South African Anti-Malarial Association.)

malarious country and so spreading the disease to healthy persons. It is essential therefore that mosquitoes should be absolutely prevented from biting malarial patients.

### Use of Quinine.

In many parts of the tropics people take quinine regularly in order to destroy or reduce the parasites in the blood. This method of avoiding or curing malaria is accepted as the best by medical men generally. Any one who has to travel through or live in a very malarious district will do well to employ quinine, not only after the fever shows up but also beforehand, as a precautionary measure against malaria.

Having considered the nature and habits of mosquitoes and their relation to malaria, and the various methods of preventing the disease by combating mosquitoes, let us now briefly discuss the nature of malaria and the life of the malarial parasites in man and in the mosquito.

## Malaria.

Although malaria does at times occur in the form of an epidemic that attracts a great deal of attention, the importance of the disease is probably largely due to its persistent endemic nature. Year by year people in malarial districts suffer from it, often having merely a slight attack. The disease has a very marked enervating effect upon the sufferer. He may be able to go on with his work, but still his productiveness is greatly impaired. So that aside from the actual death and the severe attacks that necessitate long periods of hospital treatment, the disease causes a great loss as a result of the less severe cases. Various investigators have found that a very large percentage of the native population in malarial countries harbour the malarial parasite in their blood. As a result of a long series of attacks from infancy on the individual finally becomes immune, but many die from the effects of the disease, and it is not necessarily the strongest element of the population that survives. Malaria has a very great devitalizing effect upon the population.

Sir Ronald Ross, to whom the world owes the discovery of the mode of transmission of this terrible disease, and hence the means of controlling it, has said that malaria has had a very great share in causing the gradual degeneration of Greece, once one of the strongest races on earth. The following statement made by him, and quoted by Sir Rubert Boyce in his book "Mosquito or Man," is of special interest to us in South Africa. "We may also say that it (malaria) has withheld an entire continent from humanity—the immense and fertile tracts of Africa; what we call the Dark Continent should be called the Malarious Continent; and for centuries the successive waves of civilization which have flooded and fertilized Europe and America have broken themselves in vain upon its deadly shores." The great importance of malaria as a factor in retarding the development of otherwise promising regions in South Africa, and the annual loss of life and vitality due to its attacks, are too well known to need further discussion. What is perhaps not realized sufficiently well is the fact that malaria is a preventable disease, and that intelligent concerted action on the part of municipalities and Governments, together with the co-operation of the individual, has repeatedly controlled if not entirely eradicated the disease.

Malaria is caused by a small organism, belonging to the group of the protozoa, or one celled animals, that live in the blood. The cause of the disease was for many years a perplexing problem, until Laveran, a French investigator, demonstrated, in 1880, that the parasite was present in the blood of all malarial patients.

## Life History of the Parasite.

The parasite, upon entering the blood, attacks and develops within the red blood cells (corpuscles). After a time a large number of new individuals are developed from the original one in the blood cell, and at certain regular intervals these are set free in the blood by

the breaking up of the cell. Each of these individuals then attacks a new blood cell and the process of growth and multiplication is repeated. This multiplication or spore formation causes the terrible "shakes" that are characteristic of the disease. This growth and multiplication of the parasite continues in the blood until the patient finally succumbs to the effects of the disease and dies, or until the system develops sufficient resistance to prevent or greatly retard it. Now the question naturally arises: how is the parasite carried from a sick to a healthy person? It is evident that some mode of transmission is necessary whereby the parasite in the blood of the malarial patient can be transferred to the blood of healthy persons. Not until 1897 was it finally demonstrated that mosquitoes were the agents in this transmission. Sir Ronald Ross, working in India, found the malarial parasites in the stomach wall of *Anopheles* mosquitoes. Subsequent

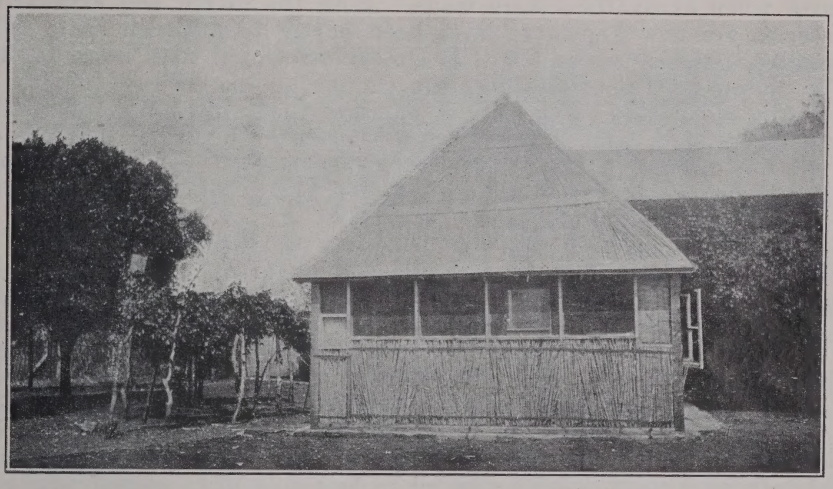

Fig. 12.—Mosquito-proof Hut.
(Loaned by South African Anti-Malarial Association.)

experimental work has repeatedly confirmed the results of Ross' work. It is therefore established beyond all possibility of a doubt that the only way in which malaria can be carried from the sick to the healthy is by the agency of mosquitoes. When an *Anopheles* mosquito bites a person who has malaria and takes some of his blood into its stomach, the malarial parasites become differentiated into male and female forms. After the female form has been fertilized by a male form, it penetrates the stomach wall of the mosquito, begins to enlarge, and causes the growth of a small wart-like lump on the outside of the stomach of the mosquito. Meanwhile the body has been divided internally into many young forms of the parasite or spores. After a few days these spores are liberated from the wart on the stomach wall into the body cavity of the mosquito. They wander about in the body fluids of the insect until they finally lodge in the salivary glands at the base of the beak or proboscis. Now when the mosquito bites a healthy person, the spores of the parasite are injected into the blood with the saliva that the mosquito injects into the wound made by its proboscis. The spores at once attack the red blood cells, and develop

and multiply as before. Thus the life cycle is completed. It will be noted that it is essential for the parasite of malaria to pass through a mosquito in order to spread from a diseased to a healthy person.

### Historical.

Malaria or "miasm" has been known for many centuries, and for a long time philosophers and medical men have speculated upon the cause and method of infection of the dreaded disease. As soon as the disease was carefully observed it was noticed that it was closely associated with marshes. Hence the word "mal-aria," denoting bad or swampy air. The idea that malarial fever was due to breathing the vapours of the marshes has through many generations become firmly established in the human mind. Even to-day there are many men who ought to know better, who still firmly believe in it. Another belief was that the fever came from the vapours that arose from the earth when excavations were made. Both the marsh and excavation theories are now known to have been partly founded on fact. The dreaded malaria was and still is closely associated with swamps, but the reason is that *Anopheles*, the carrier of the disease, breeds in swamps and pools and collections of water in excavation works. The vapours arising from the marshes or excavations have nothing to do with the disease. It will probably take a good many generations before the facts of the mosquito-borne nature of malaria will be generally known and accepted.

The relation of mosquitoes to disease was suggested by Nott as far back as 1848, and several other students of yellow fever and malaria mentioned mosquitoes as the probable transmitting agents during the period from 1850 to 1897. It was not until the latter date, however, that the mosquito theory of the transmission of malaria was finally established by Ross in India. After Ross had found the parasites of malaria in the *Anopheles* mosquito, it was shown by direct experiments that the mosquito carried the disease from the malarial patient to healthy persons. Mosquitoes were fed upon malarial patients, and subsequently allowed to bite a healthy person who was protected from other mosquitoes. After a regular incubation period a typical case of malaria developed. One of the striking cases was that of two gentlemen who were infected in London—where no malaria ordinarily occurs, by being bitten by Anopheline mosquitoes brought from Italy. A great deal of indirect proof of the relation of mosquitoes to malaria has been furnished by people living in highly malarious localities with perfect safety by protecting themselves from mosquitoes.

The anti-mosquito campaigns carried on in many parts of the world have given conclusive proof that a region can be freed from malaria by preventing the breeding of mosquitoes. The sanitary measures employed at Panama on the canal works have given the world a fine example of what can be done along the lines of anti-mosquito work. The thousands of canal workers with their families are now living in safety in a locality that has always been known as a hotbed of malaria and yellow fever. The methods employed were, in a general way, screening of houses and prevention of the breeding of mosquitoes.

### Other Aspects of the Mosquito Problem.

There are other reasons, besides the danger from malarial infection, why definite systematic work should be done in South Africa,

as elsewhere, against mosquitoes. Every one knows what a nuisance mosquitoes are in almost all parts of the Union. The comfort that would be secured by proper attention on the part of individuals, municipalities, and Governments to the mosquito plague, would in itself repay the trouble and expense involved.

Now add to the discomfort caused by mosquitoes the losses due to malaria, for which mosquitoes are responsible, and it is clear that indifference to the mosquito problem is gross neglect on our part.

In tropical and sub-tropical America yellow fever has for centuries been a terrible scourge. In 1900 it was discovered that a mosquito (*Stegomyia calopus*) was responsible for its transmission. Yellow fever is also a serious obstacle in West Africa. It may be significant that the yellow fever mosquito is common in certain parts of the Union. Elephantiasis, a disease in which certain parts of the

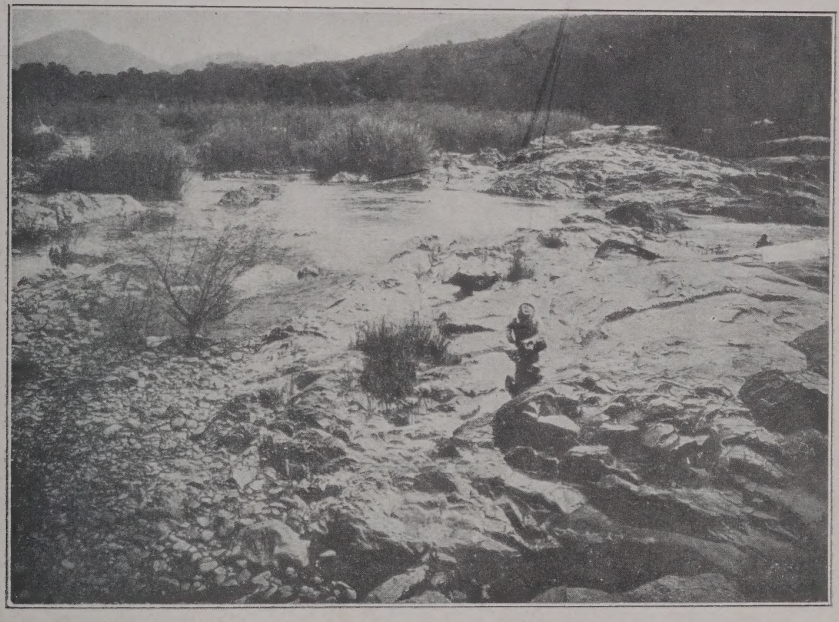

Fig. 13.—Mosquito Breeding Places. Rock Pools at Kaapmuiden, in the Low Veld.

body become very abnormally enlarged, is due to a small parasitic worm that lives in the blood. This disease is common in the more tropical parts of the Union. It is also transmitted by mosquitoes. Dengue fever is another tropical disease that is transmitted by mosquitoes. A *Culex* is the agent in this case. Horse-sickness is almost certainly transmitted by mosquitoes, as Sir Arnold Theiler has shown, and it is possible that mosquitoes will be found to be responsible for the transmission of other human and stock diseases.

## Conclusion.

It has been pointed out that malaria is an entirely preventable disease. It is conveyed from one person to another by mosquitoes, and in no other way. It follows that without mosquitoes there can be

no malaria. Mosquitoes can be very largely if not entirely prevented from biting people by means of nets and screens; their breeding in a given locality can be controlled to a great extent by the means outlined above.

A considerable amount of trouble and expense will be incurred by any individual or community in getting rid of mosquitoes and malaria. But if the work is conducted properly success is almost sure to follow. Not only in other parts of the world, but also in South Africa, actual experience has shown that the prevention of malaria is entirely possible.

Any one undertaking anti-mosquito work is sure to be rewarded by a great deal of comfort, and, more than that, he will be free from the ever present danger of malaria. Surely the results that can be attained make the effort doubly worth while.

As individuals and as a nation we owe it to ourselves and to the prosperity of South Africa to do all we can to get rid of that dreaded disease—malaria.

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